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Pore pressure induced rupture and aftershocks in the laboratory

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Three phases were observed during the pore pressurization of a intact fault gouge analog (a 14% porosity Fontainebleau sandstone) under 100 MPa confinement and 240 MPa shear stress. The first one corresponded to premonitory activity. During this phase, physical properties (i.e. elastic wave velocities and permeability) were strongly affected and decreased, due to permanent damage accumulation. More than 3 000 Acoustic Emissions (AE) were located, demonstrating the initiation of strain localization. The second phase corresponded to the initiation of a nucleation patch (˜ 1cc) which accelerated up to speeds of ˜ mm/s. Unstable rupture propagation followed at speed comprised between 0.1-10m/s. This tends to confirm the theoretical analysis of rupture nucleation performed by Ohnaka [2003]. No quiescence was observed post failure. Hence, the last phase corresponded to a large amount of aftershock triggering along the fracture plane, with a relative lack of activity where the rupture initially nucleated. A complete acoustic recording enabled us to determine Omori's law exponents of 0.92 and 1.18 pre- and post-failure respectively. Fast depressurization of the pore space induced a secondary set of aftershocks on the fracture plane, due to a lower permeability of the faulted region. Source mechanisms of these "pore-pressure induced" aftershocks reveal that the fracture is being locked and compacted as pore pressure was released. This experimental study clearly highlights the importance of pore pressure variations and normal stress redistributions in both rupture and aftershock triggering.